

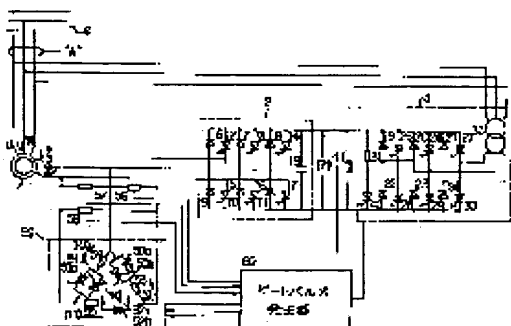
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**(54) OVERVOLTAGE PROTECTING DEVICE FOR VARIABLE-SPEED
PUMPED-STORAGE POWER GENERATION SYSTEM**



(57)Abstract:

PURPOSE: To enable a chopper circuit and a thyristor short-circuiting equipment to protect overvoltage together by suppressing overvoltage generated on short-circuiting failure using a chopper circuit, short-circuiting a secondary circuit by igniting a thyristor and then suppressing overvoltage for the overvoltage which cannot be suppressed by the chopper circuit.

CONSTITUTION: When a three-phase short-circuiting failure occurs at a point 'A', a short-circuiting current including DC component flows to the primary side of a coil winding induction machine 1, induction voltage is generated at a secondary side and a secondary current flows, thus charging a capacitor 18 and causing DC voltage (7) to increase. Then, when a protection level is reached, GTO 41 is turned on and a discharge current flows, thus

suppressing the increase in the DC voltage (7). When the DC voltage (7) further increases and reaches a set level, thyristors 50a, 50b, 51a, 51b, 52a, and 52b of a thyristor short-circuiting equipment 59 are ignited for short-circuiting a secondary circuit and protection according to the resistance ratio of a charge resistor 31 connected to the chopper circuit and resistors 53-55 connected to a thyristor short-circuiting resistor 59.

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CLAIMS

[Claim(s)]

[Claim 1] In the adjustable-speed pumped hydro power generation system which controls the secondary current of a three phase coil form induction machine by the inverter, performs adjustable-speed operation, and performs transfer of electric power system and power The DC power supply which supply direct current voltage to said inverter, and the capacitor which carries out smooth [of the direct current voltage from these DC power supply], The chopper circuit which is connected to this capacitor at juxtaposition and consists of a series circuit of a switching element and resistance, The thyristor short circuit machine which comes to carry out the delta connection of the series circuit of resistance to the thyristor component which was connected to the secondary circuit of said coil form induction machine, and connected with reverse juxtaposition, With the signal of said DC power supply, the 1st electrical-potential-difference detector which detects the electrical potential difference of the link circuit of said inverter, the 2nd electrical-potential-difference detector which detects the three phase line voltage of the secondary circuit of said coil form induction machine, and said 1st electrical-potential-difference detector Overvoltage protection equipment of the adjustable-speed pumped hydro power generation system characterized by providing a means to turn on and off the switching element of said chopper circuit, and a means to turn on and off the thyristor component of said thyristor short circuit machine with the signal of said 2nd electrical-potential-difference detector.

[Claim 2] In the adjustable-speed pumped hydro power generation system which controls the secondary current of a three phase coil form induction machine by the inverter, performs adjustable-speed operation, and performs transfer of electric power system and power The DC power supply which supply direct current voltage to said inverter, and the capacitor which carries out smooth [of the direct current voltage from these DC power supply], The thyristor short circuit machine which comes to carry out the delta connection of the series circuit of resistance to the thyristor component which was connected to the secondary circuit of said coil form induction machine, and connected with reverse juxtaposition, With the signal of the lightning arrester which operates when the electrical potential difference of the link circuit of said DC power supply and said inverter turns into an overvoltage, the 2nd electrical-potential-difference detector which detects the three phase line voltage of the secondary circuit of said coil form induction machine, and said 2nd electrical-potential-difference detector Overvoltage protection equipment of the adjustable-speed pumped hydro power generation system characterized by providing a means to turn on and off the thyristor component of said thyristor short circuit machine.

[Claim 3] In the adjustable-speed pumped hydro power generation system which controls the secondary current of a three phase coil form induction machine by the inverter, performs adjustable-speed operation, and performs transfer of electric power system and power When closed-circuit failure occurs in the upstream of said coil form induction machine, it is for controlling this generating overvoltage. Overvoltage protection equipment of the adjustable-speed pumped hydro power generation system characterized by providing the thyristor short circuit machine which comes to carry out the delta connection of the series circuit of resistance to the thyristor component which was connected to the secondary circuit of said coil form induction machine, and connected with reverse juxtaposition.

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Industrial Application] In the adjustable-speed pumped hydro power generation system which controls the secondary current of a three phase coil form induction machine by the inverter, performs adjustable-speed operation, and performs transfer of electric power system and power, this invention relates to the overvoltage protection equipment which controls a generating overvoltage, when closed-circuit failure occurs in the upstream of a three phase coil form induction machine.

[0002]

[Description of the Prior Art] Drawing 4 is the block diagram of the conventional example. In drawing, the inverter with which 1 controls a coil form induction machine and 2 controls the secondary current of the coil form induction machine 1, the DC power supply by which 3 supplies direct current voltage to an inverter 2, and 4 are electric power system. The inverter 2 consists of diodes 6-11 by which bridge connection was carried out, GTO (gate turn-off thyristor) 12-17, and a capacitor 18.

[0003] Moreover, DC power supply 3 consist of transformers 33 with the diodes 19-24 by which the bridge configuration was carried out, and GTO (gate turn-off thyristor) 25-30.

[0004] GTO32 is turned on in DC power supply 3, and when a discharging resistor 31 and GTO32 are contained and direct current voltage reaches a predetermined value exceeding rated value, to it, it protects so that a sink and direct current voltage may not become excessive about a current at a discharging resistor 31.

[0005] Drawing 5 is an operation wave form chart by the conventional example of drawing 4. For V phase primary current and (3), as for u2 phase secondary current of the coil form induction machine 1, and (5), in drawing, W phase primary current and (4) are [(1) / U phase primary current of the coil form induction machine 1 and (2) / v2 phase secondary current and (6)] w2 phase secondary currents. (7) is the direct current voltage of an inverter 2. (8) is the direct current of an inverter 2, and as shown in drawing 4, it is diodes 6-11, the bridge which consists of GTO(s) 12-17, and a current between capacitors 18. (9) is a current which flows to a discharging resistor 31.

[0006] Time of day t1 Before, to the upstream of the coil form induction machine 1, the primary current (1) of the frequency of electric power system 4, (2), and (3) flow, and, on the other hand, the secondary current (4) of the skid frequency controlled by the inverter 2, (5), and (6) flow to secondary at it.

[0007] Time of day t1 It sets, and if three-phase short circuit failure occurs at the "A" point shown in drawing 4, the short-circuit current (1) which contained in the upstream of the coil form induction machine 1 the dc component decided in the direction of the internal induced voltage vector at the time of a short circuit, (2), and (3) will flow. This current is decreased with the time constant of the primary circuit of the coil form induction machine 1 including a dc component, as shown in drawing. By the dc component of the primary current (1), (2), and (3), to secondary [of the coil form induction machine 1], the induced voltage of a frequency occurs considerable the bottom in the rotational speed of a rotator, and the secondary current (4), (5), and (6) flow. Generating of closed-circuit failure is detected, the thing which turns off an inverter 2 and GTO 12-17 then the secondary current (4), (5), and (6) are rectified by diodes 6-11, and the wave-like current shown in (8) flows into a direct current circuit. A

capacitor 18 is charged according to this current, and direct current voltage (7) rises. Time of day t2 It sets, and when direct current voltage reaches the protection level set up beforehand, GTO32 is turned on and the rise of a sink and direct current voltage (7) is controlled for the discharge current (9). And time of day t3 It sets, and GTO32 is turned off when direct current voltage (7) descends to the level set up beforehand. Overvoltage energy is absorbed by the above actuation in a chopper circuit, an overvoltage is controlled, and it usually returns to operation.

[0008]

[Problem(s) to be Solved by the Invention] With the conventional configuration described above, in order to control the overvoltage generated by closed-circuit failure only in a chopper circuit, it is necessary to make chopper capacity into the capacity which can control the overvoltage in all the fault points. When it does in this way, since it becomes large capacity and the number of components increases, dependability falls, and chopper capacity needs a large installation tooth space. Furthermore, since it becomes expensive equipment, economical efficiency will be spoiled remarkably.

[0009] As a means for solving such a trouble, as shown in drawing 6, short circuit machine 59A which carried out delta connection of the three thyristors is prepared in the secondary circuit of the coil form induction machine 1, and how to share a chopper circuit and overvoltage control can be considered. This becomes possible to make capacity of a chopper circuit small. Although this method makes the thyristor of short circuit machine 59A turn on, carries out the package short circuit of the three phase and controls an overvoltage by detection of overvoltage generating, if the thyristor of thyristor short circuit machine 59A is made to once turn on for a secondary transient dc component, an ON state will continue by this method. For this reason, when the thyristor short circuit machine of drawing 6 is used, after an overvoltage is controlled by actuation of a chopper circuit and a thyristor short circuit machine and failure is removed, special control of the inverter which makes a thyristor short circuit machine turn off is needed. For this reason, the return to operation usually takes time amount.

[0010] This invention aims at offering the overvoltage protection equipment of the small and cheap adjustable-speed pumped hydro power generation system which can usually return to operation promptly possible [protection of the overvoltage produced after closed-circuit failure generating], in order to remove the fault of equipment conventionally which was described above.

[0011]

[Means for Solving the Problem] In order to attain the above-mentioned purpose, invention corresponding to claim 1 In the adjustable-speed pumped hydro power generation system which controls the secondary current of a three phase coil form induction machine by the inverter, performs adjustable-speed operation, and performs transfer of electric power system and power The DC power supply which supply direct current voltage to said inverter, and the capacitor which carries out smooth [of the direct current voltage from these DC power supply], The chopper circuit which is connected to this capacitor at juxtaposition and consists of a series circuit of a switching element and resistance, The thyristor short circuit machine which comes to carry out the delta connection of the series circuit of resistance to the thyristor component which was connected to the secondary circuit of said coil form induction machine, and connected with reverse juxtaposition, With the signal of said DC power supply, the 1st electrical-potential-difference detector which detects the electrical potential difference of the link circuit of said inverter, the 2nd electrical-potential-difference detector which detects the three phase line voltage of the secondary circuit of said coil form induction machine, and said 1st electrical-potential-difference detector It is overvoltage protection

equipment of the adjustable-speed pumped hydro power generation system which possesses a means to turn on and off the thyristor component of said thyristor short circuit machine, with the signal of a means to turn on and off the switching element of said chopper circuit, and said 2nd electrical-potential-difference detector.

[0012] In order to attain the above-mentioned purpose, invention corresponding to claim 2 In the adjustable-speed pumped hydro power generation system which controls the secondary current of a three phase coil form induction machine by the inverter, performs adjustable-speed operation, and performs transfer of electric power system and power The DC power supply which supply direct current voltage to said inverter, and the capacitor which carries out smooth [of the direct current voltage from these DC power supply], The thyristor short circuit machine which comes to carry out the delta connection of the series circuit of resistance to the thyristor component which was connected to the secondary circuit of said coil form induction machine, and connected with reverse juxtaposition, With the signal of the lightning arrester which operates when the electrical potential difference of the link circuit of said DC power supply and said inverter turns into an overvoltage, the 2nd electrical-potential-difference detector which detects the three phase line voltage of the secondary circuit of said coil form induction machine, and said 2nd electrical-potential-difference detector It is overvoltage protection equipment of the adjustable-speed pumped hydro power generation system possessing a means to turn on and off the thyristor component of said thyristor short circuit machine.

[0013] In order to attain the above-mentioned purpose, invention corresponding to claim 3 In the adjustable-speed pumped hydro power generation system which controls the secondary current of a three phase coil form induction machine by the inverter, performs adjustable-speed operation, and performs transfer of electric power system and power When closed-circuit failure occurs in the upstream of said coil form induction machine, it is for controlling this generating overvoltage. It is overvoltage protection equipment of the adjustable-speed pumped hydro power generation system possessing the thyristor short circuit machine which comes to carry out the delta connection of the series circuit of resistance to the thyristor component which was connected to the secondary circuit of said coil form induction machine, and connected with reverse juxtaposition.

[0014]

[Function] According to invention corresponding to claim 1, the overvoltage which controls the overvoltage generated at the time of closed-circuit failure in a chopper circuit, and cannot be controlled further in a chopper circuit can share protection of an overvoltage with a chopper circuit and a thyristor short circuit machine by making the thyristor of a thyristor short circuit machine ignite, short-circuiting a secondary circuit, and controlling an overvoltage.

[0015] Moreover, according to invention corresponding to claim 2, the overvoltage which controls the overvoltage generated at the time of closed-circuit failure with a lightning arrester, and cannot be further controlled with a lightning arrester can share protection of an overvoltage with a lightning arrester and a thyristor short circuit machine by making the thyristor of a thyristor short circuit machine ignite, short-circuiting a secondary circuit, and controlling an overvoltage.

[0016] Since the resistor is furthermore connected to each arm of a thyristor short circuit machine according to invention corresponding to claim 3, the amount of transient direct current can decrease immediately, an alternating component can remain, a current zero point can be cut by this, a thyristor can be made to turn off automatically and a short-circuit current can moreover be reduced, reduction of a thyristor element number is also

possible.

[0017]

[Example] Hereafter, the example of this invention is explained based on a drawing.

Drawing 1 is the block diagram of the 1st example of this invention. In drawing, 1-33 are the same as that of the same notation of the conventional example block diagram stated by drawing 4. 40 is GTO (gate turn-off thyristor), and 31 is a discharging resistor and constitutes the chopper circuit by these. GTO40 is turned on and a current is made for a sink and direct current voltage not to become excessive at a discharging resistor 31.

[0018] The electrical-potential-difference detector 41 detects the direct current voltage of the direct current circuit of an inverter 2, and the link circuit of DC power supply 3, and gives this detection value to the gate pulse generating circuit 60. The delta connection of the 1st, 2nd, and 3rd arm is carried out so that the thyristor short circuit machine 59 may be described below. Antiparallel connection of the thyristors 50a and 50b is carried out, and, as for the 1st arm, the resistor 53 is connected to this at the serial. Similarly, antiparallel connection of the thyristors 51a and 51b is carried out, and, as for the 2nd arm, the resistor 54 is connected to this at the serial. Thus, the constituted thyristor short circuit machine 59 is installed in secondary [of the coil form induction machine 1], and short-circuits an overvoltage generating phase alternatively by igniting the thyristor of an overvoltage generating phase.

[0019] The electrical-potential-difference detectors 56, 57, and 58 detect the line voltage of the secondary circuit of the coil form induction machine 1, and give it to the gate pulse generator 60 which describes this detection value below. the level to which the gate pulse generator 60 results in actuation of GTO40 of a chopper circuit in response to the electrical potential difference detected by the electrical-potential-difference detectors 56-58 -- furthermore, a gate pulse is given to GTO40 and Thyristors 50a, 50b, 51a, 51b, 52a, and 52b, when it judges and level of operation is reached, the level which results in actuation of the thyristor short circuit machine 59, or.

[0020] Drawing 2 is an example of the gate pulse generator 60. level command value (protection level) LIH* which 61 makes turn on a chopper circuit GTO40 in drawing Level command value LIL* which the command machine to give and 62 make turn off GTO40 similarly The command machine to give and 63 are comparators. Command value LIH* from the command machines 61 and 62, and LIL* The direct-current-voltage value which the electrical-potential-difference detector 41 in drawing 1 detected is compared. A detection direct-current-voltage value is on-level command value LIH* of GTO40 of a chopper circuit. When it exceeds, an ON signal is given to GTO40 of a chopper circuit, and a detection direct-current-voltage value is off level command value LIL* of GTO40. An off signal is given to GTO40 when it becomes below. 64 is command value (level of operation) L2 * of level which makes the thyristor of the thyristor short circuit machine 59 turn on. It is the command machine to give. 65 is a comparator and is command value L2 * from the command machine 64. Each phase line voltage of the secondary circuit of the coil form induction machine 1 detected with the electrical-potential-difference detectors 56, 57, and 58 is compared, and a detection value is of operation level command value L2 * of the thyristor short circuit machine 59. An ON signal is given to the thyristor of an overvoltage generating phase (overvoltage generating arm) when exceeding.

[0021] Drawing 3 is a wave form chart for explaining actuation of the example equipment described above, and is the wave of the part as (1)(1) of operation wave form chart by conventional example of drawing 5 - (7) where - (7) is the same. (8) is a gate pulse signal given to GTO40 of a chopper circuit. As for the short-circuit current to

which (9) flows to u2-v2 interphase of the secondary circuit of the former inductor 1, and (10), a v2-w2 interphase short-circuit current and (11) are w2-u2 interphase short-circuit currents.

[0022] Time of day t1 Before, to the upstream of the coil form induction machine 1, the primary current (1) of the frequency of electric power system 4, (2), and (3) flow, and, on the other hand, the secondary current (4) of the skid frequency controlled by the inverter 2, (5), and (6) flow to secondary at it. Time of day t1 If three-phase short circuit failure occurs at the "A" point which is set and is shown in drawing 1, the short-circuit current (1) which contained in the upstream of the coil form induction machine 1 the dc component decided in the direction of the internal induced voltage vector at the time of a short circuit, (2), and (3) will flow. This current is decreased with the time constant of the primary circuit of the coil form induction machine 1 including a dc component, as shown in drawing. By the dc component of the primary current (1), (2), and (3), to secondary [of the coil form induction machine 1], the induced voltage of a frequency occurs considerable the bottom in the rotational speed of a rotator, and the secondary current (4), (5), and (6) flow. It is rectified by diodes 6-11 and the secondary current (4), (5), and (6) flow into a direct current circuit. A capacitor 18 is charged according to this current, and direct current voltage (7) rises. time of day t2 Protection level LIH* which was set and direct current voltage (7) set up beforehand the time of reaching -- GTO40 - - turning on -- the discharge current -- the rise of a sink and direct current voltage (7) -- controlling -- time of day t3 setting -- direct current voltage (7) -- level LIL* set up beforehand up to -- GTO40 is made to turn off when it descends

[0023] An overvoltage cannot be controlled, but the rise of direct current voltage (7) moves only by actuation of a chopper circuit further, and it is time of day t4. It sets and is protection level L2 *. When it reaches, an overvoltage is controlled by making the thyristors 50a, 50b, 51a, 51b, 52a, and 52b of the thyristor short circuit machine 59 ignite, and short-circuiting a secondary circuit.

[0024] Direct current voltage (7) is of operation level L2 * of the thyristor short circuit machine 59. When it reaches and the thyristor short circuit machine 59 operates, a fault current is distributed to the thyristor short circuit machine 59 and a chopper circuit by the ratio of the discharging resistor 31 connected to GTO40 of the resistance 53-55 connected to the thyristor short circuit machine 59, and a chopper circuit. The thyristor short circuit machine 59 shares protection of the secondary overvoltage according to this resistance ratio.

[0025] According to the example equipment described above, overvoltage protection can be shared according to the resistance ratio of the charge resistor 31 connected to the chopper circuit, and the resistors 53-55 connected to the thyristor short circuit machine 59.

[0026] The method which performs overvoltage protection only in a chopper circuit has a large dimension, and since there are many components, if a tooth-space side and dependability are taken into consideration, this example equipment is effective.

Moreover, since, as for this example equipment, the thyristor short circuit machine 59 carries out a selection short circuit, a surplus fault current does not flow in into the thyristor short circuit machine 59. Therefore, since the capacity of the resistance 53-55 linked to the thyristor short circuit machine 59 may be small, there are few increments in the dimension by having connected resistance 53-55, reduction of a thyristor element number is also possible, and, thereby, a dimension becomes small as a whole.

[0027] Furthermore, the control means for making the thyristor of the thyristor short circuit machine with which gate actuation of a complicated inverter is demanded turn off becomes unnecessary [this example equipment], and the return to usual operation

after failure was removed becomes quick in connection with this.

[0028] Moreover, according to this example equipment, since the overvoltage protection equipment of a small and cheap adjustable-speed pumped hydro power generation system is realizable, the economical effectiveness is remarkable. Since resistors 53-55 are connected to the thyristor short circuit machine 59, the amount of transient direct current can decrease immediately, an alternating component can remain, a current zero point can be cut for this alternating component with the thyristor short circuit vessel 59, and a thyristor can be made to turn off automatically with this example equipment furthermore.

[0029] Moreover, in this example, a secondary overvoltage can be controlled in parallel with both a chopper circuit and the thyristor short circuit vessel 59 by performing a selection short circuit. This invention is not limited to the example described above, for example, may be constituted as follows. The same operation effectiveness as the example mentioned above also as a configuration which used the lightning arrester instead of the 1st electrical-potential-difference detector 41 of the chopper circuit which consists of a series circuit of the switching element GTO40 and the charge resistor 31 of the example of drawing 1, and a direct-current link circuit is acquired.

[0030] That is, the overvoltage which controls the overvoltage generated at the time of closed-circuit failure with a lightning arrester, and cannot be further controlled with a lightning arrester can share protection of an overvoltage with a lightning arrester and a thyristor short circuit machine by making the thyristor of a thyristor short circuit machine ignite, short-circuiting a secondary circuit, and controlling an overvoltage.

[0031] Moreover, although the 1st example explained the case where GTO was used as a switching element which operates a chopper circuit, other switching elements which have a rectification function may be used. Furthermore, bidirectional thyristors, such as a triac, may be used and constituted instead of the thyristor which carried out antiparallel connection. Moreover, although the case where GTO was used as a switching element which constitutes an inverter 2 was explained, the thyristor circuit which has a transistor, and other self-extinction of arc form switching elements or forced commutation circuits may constitute an inverter using other switching means.

[0032]

[Effect of the Invention] According to this invention, the overvoltage protection equipment of the small and cheap adjustable-speed pumped hydro power generation system which can usually return to operation promptly possible [protection of the overvoltage produced after closed-circuit failure generating] can be offered.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] The block diagram showing the 1st example of this invention.

[Drawing 2] The control-block Fig. showing an example of the gate pulse generator of drawing 1.

[Drawing 3] The wave form chart for explaining an operation of the example of drawing 1.

[Drawing 4] The block diagram showing a conventional example.

[Drawing 5] The operation wave form chart for explaining actuation of a conventional example of drawing 4.

[Drawing 6] The block diagram of the thyristor short circuit machine which consists of

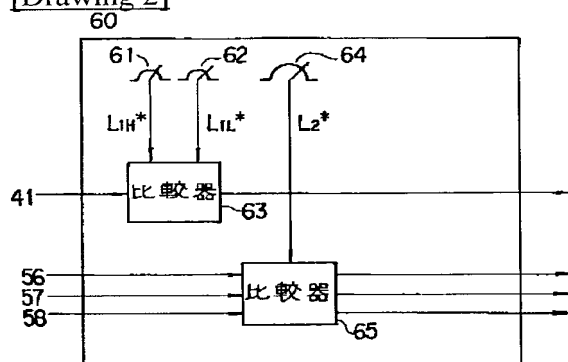
the thyristor of the conventional one direction.

[Description of Notations]

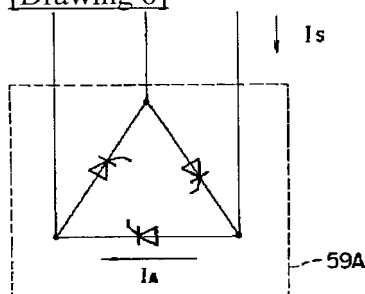
1 [-- Electric power system,] -- A coil form induction machine, 2 -- An inverter, 3 -- DC power supply, 4 6-11 [-- Diode,] -- Diode, 12-17 -- GTO, 18 -- A capacitor, 19-24 25-30 [-- GTO which constitutes a chopper circuit,] -- GTO, 31 -- A discharging resistor, 33 -- A transformer, 40 41 [-- An electrical-potential-difference detector, 59 / - - A thyristor short circuit machine, 60 / -- Gate pulse generator.] -- An electrical-potential-difference detector, 50a-52a, 50b-52b -- A thyristor, 53-55 -- A resistor, 56-58

DRAWINGS

[Drawing 2]

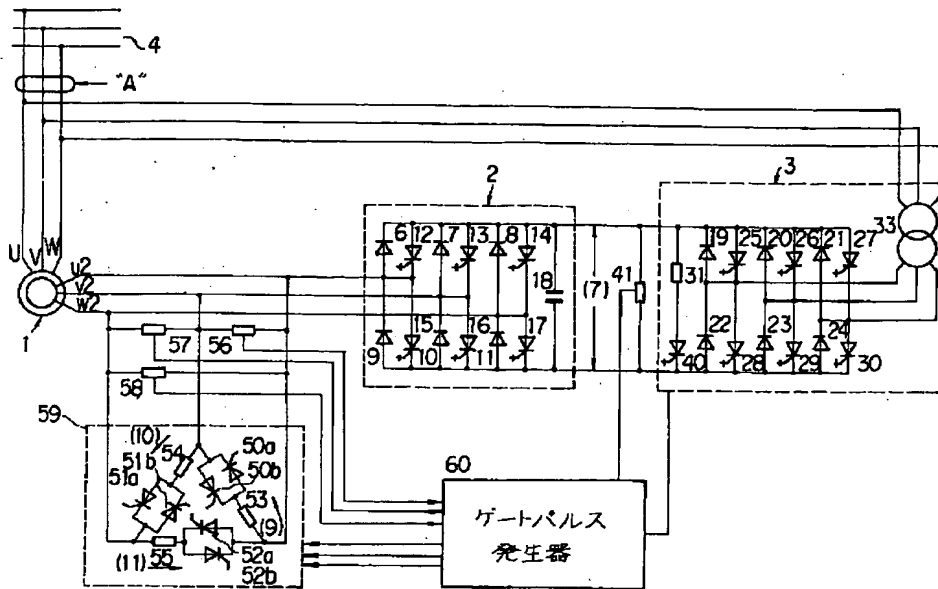


[Drawing 6]

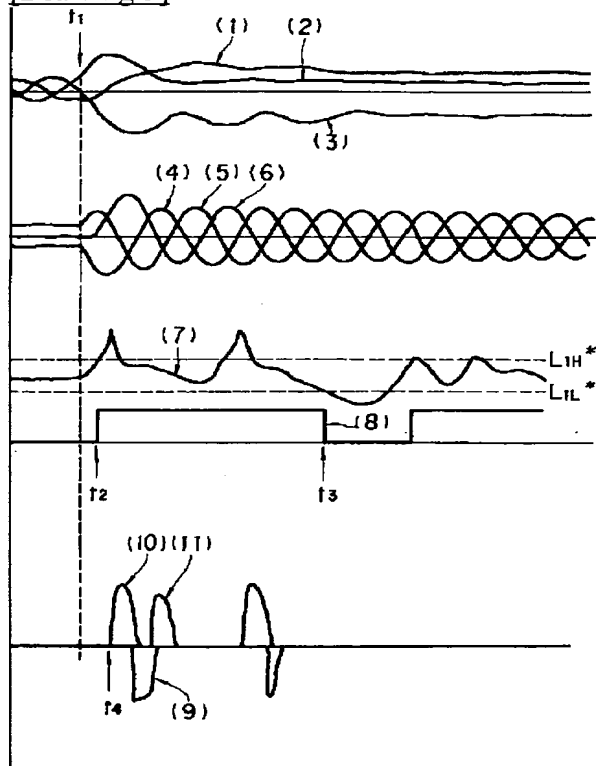


[Drawing 1]

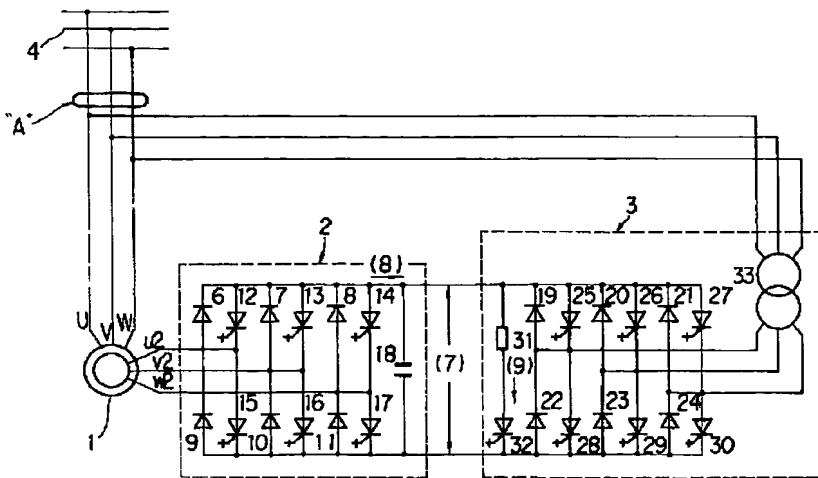
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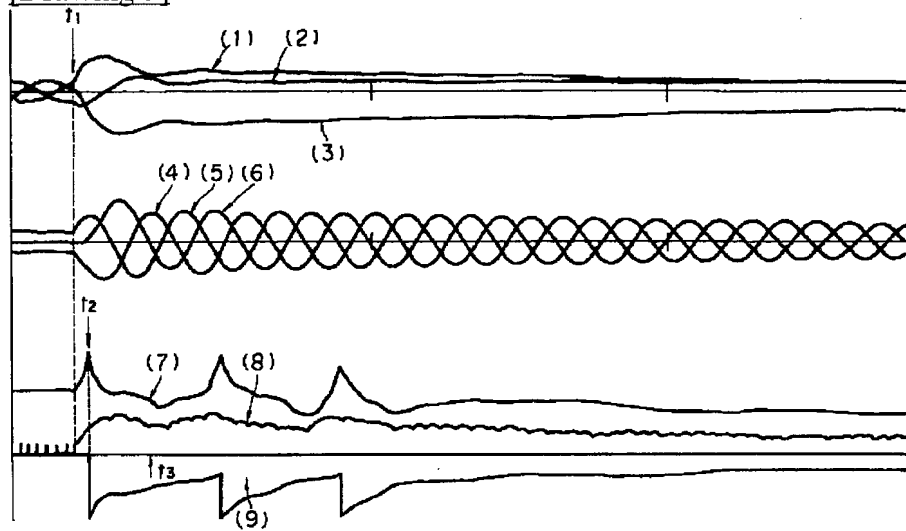
[Drawing 3]



[Drawing 4]



[Drawing 5]



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